EFFECT OF INTENSIVE DANCE-EXERCISE INTERVENTION ON BRAIN PLASTICITY IN HEALTHY SENIORS AND PATIENTS WITH MILD COGNITIVE IMPAIRMENT

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Abstract: Intensive dance-exercise intervention leads to cortical thickening in the inferior temporal and lateral occipital cortices of the right hemisphere that are engaged in the ventral visual pathway; and to the increase in resting-state functional connectivity within the frontoparietal control network, i.e. the cognitive brain network that controls visual attention tasks. Subjects undergoing an active intervention improved in the five-point task that evaluates particularly executive functions. These findings show that 6-month intensive non-pharmacological intervention may enhance distinct brain plasticity and executive functions in a mixed cohort of healthy seniors and patients with mild cognitive impairment. Further longitudinal studies should examine whether it may also prevent/postpone cognitive decline and dementia in this population.

Keywords: dance, aerobic exercise, healthy seniors, mild cognitive impairment, cortical thickness, resting state functional connectivity, fMRI, frontoparietal control network

1 INTRODUCTION

Dementia, most commonly caused by Alzheimer's disease, is one of the most alarming age-related diseases, leading to the loss of socioeconomic status and personal identity. Despite very intense pharmacological research, a new potent drug is not expected in the near future. Therefore, increasing attention is being given to preventative and affordable non-pharmacological approaches, such as physical activity. The human brain is capable of reorganizing and modifying its functions by learning new skills as well as repeating previously learned activities. Psychological studies have shown the positive impact of excercise on attention, memory and executive functions[1]. The aim of this study was to evaluate the impact of intensive dance-excercise intervention on cognition and brain plasticity in healthy seniors (HC) and patients with mild cognitive impairment (MCI).

2 METHODS

Our cohort consisted of 62 subjects: 42 HC and 20 MCI, that were divided into dance intervention group (DI; n=31) and control group (life as usual – LAU; n=31). The DI group underwent a six-month aerobic dance-excercise intervention composed of a total of 50 training units, each lasting for 60 minutes. All participants were evaluated twice – at the beginning of the study and again after 6 months – in terms of physical fitness, neuropsychology and MRI examination.

2.1 CORTICAL THICKNESS (CT)

CT is the distance between white and pial surfaces. It was assessed using Freesurfer 6.0 (http://surfer.nmr.mgh.harvard.edu). T1-weighted MRI data entered the longitudinal pipeline resulting into segmented images and cortical thickness maps on the common template for both timepoints in each subject. Upon completion of each step, gray and white matter boundaries were visually inspected, eventually manually corrected, for each subject. Seven subjects (3 DI and 4 LAU) were excluded due to segmentation imprecisions. CT maps were then resampled onto fsaverage subject and smoothed with FWHM of 15 mm. CT maps that showed difference between timepoints (timepoint 1 – timepoint 2) were calculated for each subject. These maps were then entered into general linear model and assessed by one-sample t-test with removing the effects of age, gender, education and MR scanner as covariates of no interest.

2.2 FUNCTIONAL CONNECTIVITY

Functional connectivity mapping mostly uses the change of oxygenated and deoxygenated blood ratio in the site of neuronal acivity. Resting state BOLD MRI data (200 scans) were preprocessed using SPM 12 toolbox and Matlab 2014b. Preprocessing included realignment and unwarping, normalization into standard anatomical space (MNI) and spatial smoothing with 5 mm FWHM. The level of motion was thoroughly checked in terms of frame-wise displacement (FD)[2]. No FD was higher than 3 mm (voxel size). Scans that displayed FD>0.75 mm were scrubbed[2]. No more than 2.5% of subject scans were removed. In addition, the six movement regressors (obtained during realignment and unwarping), FD and extracted signals from white matter and cerebrospinal fluid were regressed out of the data in subsequent analysis.

Altogether 22 DI and 17 LAU entered the following analyses. Representative seeds (spheres with 6 mm radius) of 4 large-scale functional networks were chosen according to the publication Gao et Lin (2012)[3]. Mean seed signals were extracted and correlation matrix was calculated for each subject. Pearson's correlation coefficients were converted to z values using Fisher r-to-z transformation. The within-network connectivity of these networks was calculated as the average of z values within a network seed pairs. Wilcoxon signed-rank test was used to assess the change in the network connectivity in time.

3 RESULTS

3.1 CORTICAL THICKNESS

Whole-brain CT analysis showed significant cortical thickening in one cluster in DI group. The cluster included inferiortemporal/lateraloccipital/middleoccipital regions of right hemisphere, see Figure 1. This cluster with size of 1367 mm2 survived multiple comparisons correction using both precached clusterwise Monte Carlo simulation with 10,000 iterations with the absolute vertex-wise cluster-forming threshold of p=0.01 and cluster-wise threshold of p=0.05, and Bonferroni correction for two hemispheres. When comparing DI and LAU groups at the baseline, no significant difference was found. The change of average CT in the cluster assessed with Mann-Whitney test between DI and LAU groups proved the significant thickening in the DI group compared to LAU group (p=0.011).

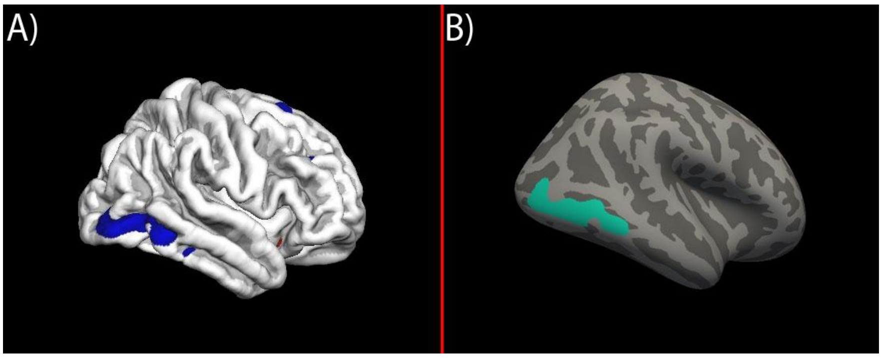

Figure 1: Cortical thickening in DI group. Displayed at: A) threshold p<0.01 uncorrected, B) after multiple comparisons correction on inflated surface.

3.2 FUNCTIONAL CONNECTIVITY

There has been significant increase in the within-network connectivity of frontoparietal control network (FPCN) in DI group (p=0.028). When comparing DI and LAU groups at the baseline, no significant difference was found. The change of FPCN connectivity assessed with Mann-Whitney test between DI and LAU groups proved almost significant increase in the DI group compared to the LAU group (p=0.055).

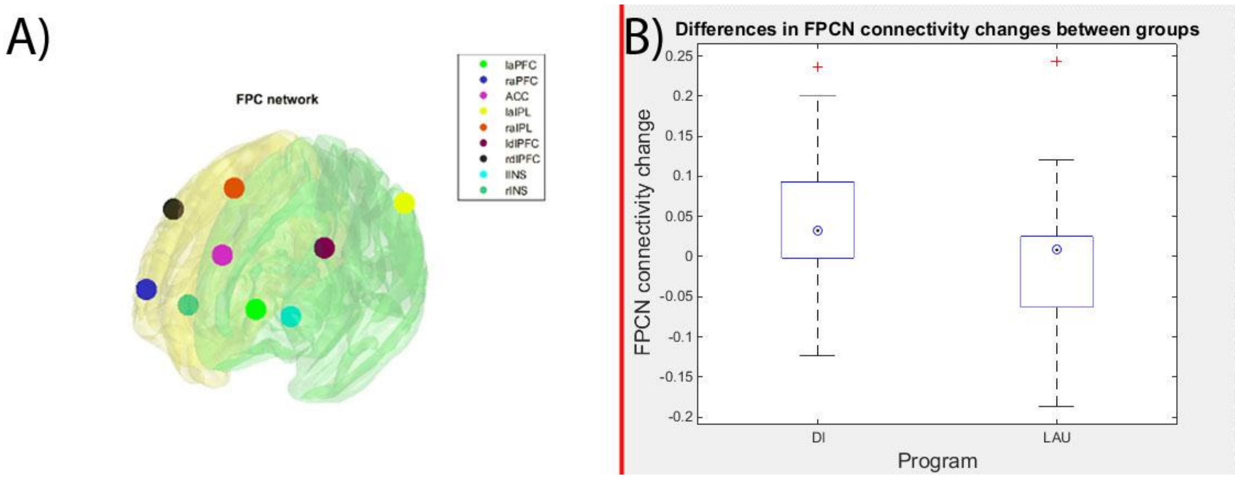

Figure 2: A) Visualization of FPCN network seeds (r/l – right/left, aPFC – anterior prefrontal cortex, ACC – anterior cingulate cortex, aIPL – anterior inferior parietal lobule, dlPFC – dorsal lateral prefrontal cortex, INS – insula), B) Boxplot showing significant increase in FPCN connectivity in DI group in comparison to LAU group.

4 CONCLUSION

Intensive dance-exercise intervention induced cortical thickening in the inferior temporal and lateral occipital cortices of right hemisphere, and the increase in FPCN connectivity. We plan to verify these results on larger healthy seniors and MCI separate cohorts and examine behavioural, physical and clinical correlates of the described changes.

ACKNOWLEDGEMENT

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